

AD-A065 896

FLEET WEATHER CENTRAL/JOINT TYPHOON WARNING CENTER FP--ETC F/6 4/2
MODIFIED TWENTY-FOUR HOUR EXTRAPOLATION AS A FORECAST TECHNIQUE--ETC(U)
APR 76 C R SIKORA

UNCLASSIFIED

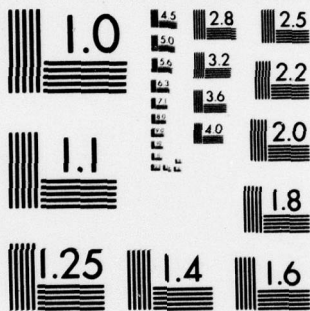
FLEWEACEN/JTWC-TN-76-4

NL

| OF |
AD
A065896



END
DATE
FILMED
5-79
DDC



2

①

**FLEWEACEN TECH NOTE:
JTWC 76-4**

LEVEL II

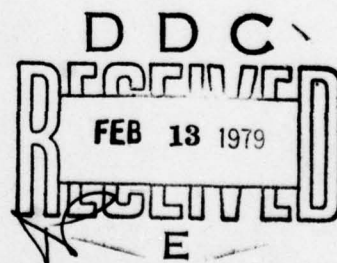
**MODIFIED TWENTY-FOUR HOUR
EXTRAPOLATION AS A FORECAST
TECHNIQUE FOR THE MOVEMENT
OF TROPICAL CYCLONES**

by

**CAPT CHARLES R. SIKORA
APRIL 1976**

AD A0 65896

DDC FILE COPY



**U.S. FLEET WEATHER CENTRAL GUAM
BOX 12 COMNAVMARIANAS
F.P.O. SAN FRANCISCO, CALIFORNIA 96630**

DISTRIBUTION STATEMENT A

**Approved for public release;
Distribution Unlimited**

79 02 09 042

ACCESSION for	
NTIS	White Section <input checked="" type="checkbox"/>
DDC	Buff Section <input type="checkbox"/>
UNANNOUNCED	<input type="checkbox"/>
JUSTIFICATION	
BY	
DISTRIBUTION/AVAILABILITY CODES	
Dist.	AVAIL. and/or SPECIAL
A	-

File on file

14
 FLEWEACEN/TECH NOTE:
 JTWC - 76-4
 TN-76-4

6
 MODIFIED TWENTY-FOUR HOUR
 EXTRAPOLATION AS A FORECAST
 TECHNIQUE FOR THE MOVEMENT
 OF TROPICAL CYCLONES.

BY
 9 Technical note
 1973-1975

10
 CAPTAIN CHARLES R. SIKORA

11
 APR 1976

12 18p.

U. S. FLEET WEATHER CENTRAL GUAM
 BOX 12 COMNAVMAIANAS
 F. P. O. SAN FRANCISCO, CALIFORNIA 96630

408 282

LB

79 02 09 042

CONTENTS

ABSTRACT.....	iv
LIST OF TABLES AND FIGURES.....	v
1. INTRODUCTION.....	1
2. METHOD.....	2
3. RESULTS.....	4
4. SUMMARY.....	10
REFERENCES.....	11

ABSTRACT

The Joint Typhoon Warning Center, Guam (JTWC) uses several objective techniques for forecasting the movement of tropical cyclones. Twelve-hour extrapolation (XTRP) and the TYFN75 analog program are the most successful of these techniques. The input parameters for both techniques include the past 12-hr storm position. It is felt that a subjective 24-hr extrapolation technique (XT24) based on reconnaissance positions is more realistic: (1) these data are real-time whereas the warning positions are extrapolated from the reconnaissance positions and (2) a 24-hr period tends to smooth out erratic short-term movements in the storm track. An operational evaluation of XT24 was conducted during the 1975 typhoon season. These results and recommendations for future use are discussed.

LIST OF TABLES AND FIGURES

Tables

1. Forecast position error (nm) for various categories of reconnaissance platforms (1973 and 1974 composite data). The number of cases is shown in parentheses (Harrison, 1975).....3-4
2. Objective forecast techniques for 17 typhoons from 1973 and 1974..... 5
3. Objective forecast techniques for selected typhoons (10) from 1973 and 1974..... 6
4. Objective forecast techniques for 13 typhoons from 1975.....7-9

1. INTRODUCTION

The official Joint Typhoon Warning Center (JTWC) warning is the culmination of a complex series of events which begins with the obtaining of a reconnaissance position (fix). To be suitable for warning purposes, a fix must be obtained 2 to 3½ hr prior to the scheduled warning time. Fixes obtained earlier are essentially too old for the warning time while fixes obtained later do not permit sufficient time for preparation of the warning. Once a warning fix has been obtained and plotted, the warning position is determined by extrapolation. For example, a fix obtained at 0930Z is the basis for extrapolation to 1200Z using the current storm speed for movement. The computerized objective forecast techniques are then run, and from these forecasts a preliminary forecast track is derived out to 72 hr. This track is evaluated subjectively for consistency and compatibility with climatology and the current synoptic situation and modified as necessary.

At the present time, 12-hr extrapolation (XTRP) is the best objective technique for forecasting the 24- and 48-hr movement of tropical cyclones. XTRP uses the past 12-hr preliminary best track position and the current warning position as end points. The past 12-hr preliminary best track position is defined as that position best fitting all reconnaissance and supporting data available. The current warning position is determined by extrapolation as described above. A straight line is then drawn through these two points and becomes the forecast track. The speed of movement of the past 12-hr period is used as the forecast speed out to 48-hr.

The next most successful objective technique is the TYFN75 analog program (Jarrell and Wagoner, 1973). This program searches history data tapes for those tropical cyclones with characteristics similar to the current storm. Twenty-one acceptance parameters are considered, with the most critical being the present position and the past 12-hr location and movement of the storm.

During everyday operational application, it was observed that use of the past 12-hr preliminary best track position would frequently result in a "windshield wiper" effect for a series of warnings. This effect is the result of short term trends (based on consecutive fix positions) which indicate that significant changes in the direction of movement are possible warranted in the forecast storm track. Colon's (1953) investigation of 24-hr persistence (to forecast the direction of movement only) in the Atlantic showed that its

probability of success for at least the first 24-hr forecast was quite high in the more southerly latitudes of the Caribbean Sea and the eastern Atlantic. Riehl and Sanborn (1958) in a compilation of the three-day mean tracks for hurricanes, found that for storms in low latitudes, the general tendency is to preserve the initial direction of motion. Based on these observations, a subjective technique employing 24-hr extrapolation (XT24) was evaluated.

2. METHOD

Fifteen typhoons from 1974 and two from 1973 were utilized in an initial after-the-fact evaluation of XT24. The latest available fix position (upon which the JTWC warning was based), and that reconnaissance position 24-hr ago ± 6 hr were used as the end points for linear extrapolation out to 72-hr. The speeds of the official JTWC forecast were used for movement. It should be noted that for storms which JTWC was forecasting to recurve, the official JTWC speed for the 24-hr forecast was also used for the 48- and 72-hr forecast. This was done to eliminate the inconsistency of using speeds of movement of 5 to 10 kt (2.6 to 5.1 m sec⁻¹) as a storm slows down prior to recurvature and then speeds up 20 to 35 kt (12.9 to 18.0 m sec⁻¹) after recurvature. These speeds were used in lieu of the past 24-hr speed (persistence) for several reasons. Storms moving faster or slower than climatology do not usually maintain these speeds for 48 to 72 hr. Persistence also cannot take into account such factors as terrain influences (storms crossing the Philippines, for example, exhibit a dramatic increase in speed), rate of development, and the position and amplitude of middle and upper tropospheric features. The JTWC speeds are determined subjectively after an evaluation of all available data.

The reconnaissance positions are used as end points in lieu of the warnings positions for several reasons. First, they are based on real-time data while the current warning position is simply extrapolated from what is considered the best reconnaissance position, thereby introducing additional error. During the period 1969-1974, the average warning position error was 19 nm for all typhoons in the JTWC area of responsibility. Furthermore, at the time any warning is being prepared, it is not possible to know the absolute warning position accuracy; this can only be determined by detailed post-season analysis. Additionally, as mentioned previously, tropical cyclones often behave quite erratically over a 12-hr period and it is difficult to ignore short-term trends which indicate that a radical change in the forecast

track is possibly warranted. Thus, the 24-hr reconnaissance position is used in an attempt to smooth out short-term trends. It is also significant that although JTWC heavily considers the 500 mb prognosis for tropical cyclone steering, it has been observed that once a storm becomes well-organized (and in the absence of a well-defined ridge or trough), its circulation can effectively mask the steering flow over a considerable area. It then becomes difficult to separate the basic steering current from the circulation surrounding the storm. In the western Pacific, this is primarily true below 20N where the steering flow is generally easterly at 10-20 kt ($5.1 - 10.3 \text{ m sec}^{-1}$). Above 20N, strong westerlies dominate with short-wave troughs and an occasional long-wave trough moving off mainland China. Here, a tropical cyclone may more realistically be considered a point vortex embedded in a broad-scale flow pattern of 30 kt (15.4 m sec^{-1}) or greater.

Due to the nature of this self-steering concept, and for the reasons outlined above, it was felt that XT24 should be an improvement over XTRP and a valuable input to the official JTWC forecast. Since aircraft reconnaissance provides the most accurate and reliable fix data (Table 1), XT24 was based in order of preference as follows: (1) aircraft fixes; (2) land radar; (3) satellite eye fixes; and (4) satellite fixes other than eye fixes.

Table 1. Forecast position error (nm) for various categories of reconnaissance platforms (1973 and 1974 composite data). The number of cases is shown in parentheses (Harrison, 1975).

a. All Forecasts (Tropical Depressions, Tropical Storms, and Typhoons.

PLATFORM	FORECAST INTERVAL		
	WARNING	24-HR	48-HR
Aircraft	18 (466)	111 (410)	207 (261)
DMSP Satellite	25 (358)	119 (248)	226 (126)
Radar	17 (61)	125 (36)	228 (22)
Other	43 (93)	151 (43)	---

b. Forecasts for Typhoons (when maximum winds were 35 kt or greater).

PLATFORM	FORECAST INTERVAL		
	WARNING	24-HR	48-HR
Aircraft	16 (323)	106 (299)	200 (229)
DMSP Satellite	20 (205)	103 (162)	228 (111)
Radar	15 (39)	115 (26)	210 (20)
Other	36 (29)	122 (11)	---

From the results in Table 2, several general conclusions were drawn. Note in Table 2 and subsequent tables, that "X-AXIS" refers to the techniques listed horizontally, while "Y-AXIS" refers to those listed vertically. The example in Table 2 compares XTRP to XT24. In 326 cases available for comparison, the average 24-hr vector error for XTRP was 116 nm, while that for XT24 was 117 nm. The difference in accuracy between these two techniques was 1 nm. For all typhoons, XT24 compared favorably with JTWC and XTRP. When those tropical cyclones moving east, northeast, etc. and/or above 20N were eliminated from the verification, XT24 was a marked improvement over JTWC at 72-hr and XTRP at 48-hr (Table 3). Of course, it should be remembered that westward moving tropical cyclones below 20N may recurve, loop, or otherwise behave quite erratically. It should also be noted that in the absence of a steering flow to cause recurvature above 20N, XT24, may still be applicable.

Based on the positive results from this evaluation, XT24 was used operationally during the 1975 typhoon season with one modification. Due to the increased time span of 24-hr between end points, it was felt that the 24-hr ± 6 hr reconnaissance position could be replaced by the past 24-hr preliminary best track position. This extended period permits sufficient time to evaluate additional data and establish an accurate position.

3. RESULTS

The forecast verification data for the 1975 typhoon season are presented in Table 4. Twenty-four hour extrapolation is verified against TYFN75 (only those analogs moving generally westward), XTRP, and HPAC which is the average of climatology and 12-hr persistence. XTRP was slightly more accurate for

Table 2. Objective forecast techniques for 17 typhoons from 1973 and 1974.

24-HOUR

JTMC XTRP XT24

JTMC 344 107
107 0

XTRP 327 107 327 116
116 9 116 0

XT24 343 107 326 116 343 117
117 10 117 1 117 0

48-HOUR

JTMC XTRP XT24

JTMC 259 207
207 0

XTRP 248 204 248 215
215 11 215 0

XT24 259 207 248 215 259 220
220 13 217 2 220 0

72-HOUR

JTMC XT24

JTMC 176 327
327 0

XT24 176 327 176 326
326 -1 326 0

NUMBER OF CASES	X-AXIS TECHNIQUE ERROR
Y-AXIS TECHNIQUE ERROR	ERROR DIFFERENCE Y-X

JTMC - Official JTMC Subjective Forecast
XTRP - 12-Hr Extrapolation
XT24 - Modified 24-Hr Extrapolation

JTMC - Official JTMC Subjective Forecast
XTRP - 12-Hr Extrapolation
XT24 - Modified 24-Hr Extrapolation

Table 3. Objective forecast techniques for selected typhoons from 1973 and 1974.

<u>24-HOUR</u>				
	<u>JTWC</u>	<u>XTRP</u>	<u>XT24</u>	
JTWC	215 103	103 0		
XTRP	208 114	104 11	208 114 114 0	
XT24	215 105	103 2	208 105 -9	215 105 105 0
<u>48-HOUR</u>				
	<u>JTWC</u>	<u>XTRP</u>	<u>XT24</u>	
JTWC	171 199	199 0		
XTRP	166 207	199 8	166 207 0	
XT24	171 186	199 -14	166 186 -21	171 186 186 0
<u>72-HOUR</u>				
	<u>JTWC</u>	<u>XT24</u>		
JTWC	121 331	331 0		
XT24	121 256	331 -75	121 256 0	

NUMBER OF CASES	X-AXIS TECHNIQUE ERROR
Y-AXIS TECHNIQUE ERROR	ERROR DIFFERENCE Y-X

JTWC - Official JTWC Subjective Forecast
XTRP - 12-Hr Extrapolation
XT24 - Modified 24-Hr Extrapolation

Table 4. Objective forecast techniques for 13 typhoons from 1975.

	<u>24-HOUR ERRORS</u>											
	JTWC	XTRP	HPAC	TYFC	TYFS	TYFR	MH70	MH50	XT24			
JTWC	221 130 130 0											
XTRP	205 130 142 12	205 142 0										
HPAC	183 128 135 7	182 138 -3	183 135 0									
TYFC	59 121 134 13	57 145 -11	53 121 132 11	59 134 0								
TYFS	195 127 144 18	184 135 10	165 130 140 11	54 137 -1	195 144 0							
TYFR	204 130 144 14	193 141 2	177 136 140 5	59 134 12	190 144 0	204 144 0						
MH70	144 133 159 26	143 148 12	126 137 145 8	37 101 40	128 149 -1	137 142 12	144 159 0					
MH50	138 133 144 11	136 148 -5	119 137 134 -3	37 102 13	122 151 -13	131 143 0	137 160 -17	138 144 0				
XT24	177 130 149 19	173 140 9	169 136 150 14	50 134 -3	158 144 -4	169 139 12	121 146 -2	114 137 8	177 149 0			

48-HOUR ERRORS

	JTWC	XTRP	HPAC	TVFC	TVFS	TYFR	MH70	MH50	XT24
JTWC	165 288 288 0								
XTRP	153 279 321 32	153 321 321 0							
HPAC	133 280 251 -30	132 288 252 -37	133 251 251 0						
TVFC	49 300 341 41	47 369 341 -28	41 249 289 41	49 341 341 0					
TVFS	153 285 359 74	144 318 -61 42	125 243 338 94	48 344 442 98	154 358 358 0				
TYFR	157 289 300 11	148 319 298 -21	129 250 274 24	49 341 358 16	153 358 298 -59	158 300 300 0			
MH70	98 291 357 66	97 343 360 18	81 249 299 50	26 341 521 180	91 377 354 -23	95 299 354 55	98 357 357 0		
MH50	96 292 356 64	94 344 358 14	78 249 276 27	26 347 443 96	89 381 -24	93 302 358 56	95 358 355 -3	96 356 356 0	
XT24	129 277 273 -5	126 290 272 -19	121 250 274 24	39 276 230 -46	122 331 265 -66	126 275 271 -4	80 298 273 -25	77 281 271 -11	129 273 273 0

72-HOUR ERRORS

	JTWC	TYFC	TYFS	TYFR	MH70	MH50	XT24
JTWC	113 441 441 0						
TYFC	34 472 520 48	35 520 520 0					
TYFS	108 444 545 101	35 520 588 69	110 538 538 0				
TYFR	108 444 440 -4	35 520 572 52	110 538 444 -94	111 445 445 0			
MH70	57 432 504 72	15 511 664 153	57 529 508 -21	58 454 504 50	59 498 498 0		
MH50	58 435 485 50	17 520 531 11	58 534 497 -37	59 462 495 33	58 497 484 -13	60 488 488 0	
XT24	82 438 394 -44	26 519 332 -187	82 536 392 -144	82 421 392 -29	46 486 356 -130	45 439 352 -87	83 393 393 0

the 24-hr forecast, while XT24 was more accurate out to 48- and 72-hr. Suprisingly, XT24 was more accurate than the JTWC official forecast and all of the objective forecast techniques for the 72-hr forecast. This appears to be partially due to the fact that even though tropical cyclones rarely move in a straight line, their erratic behavior when averaged over a period of 72-hr and in the absence of a significant upper-level steering flow (e.g., to cause recurvature) can often be approximated by a straight line (e.g., by the use of XT24). This is similar to the finding of Riehl and Sanborn (1958) which was discussed earlier.

4. SUMMARY

Most significantly, this study has demonstrated that persistence (and climatology) can be important inputs to the official JTWC forecast out to 72-hr. In addition, a longer time period of 24-hr permits the smoothing out of short-term trends which may be misleading indications of a storm's future movement. XT24 illustrates considerable skill as a forecast technique for the movement of tropical cyclones beyond 24-hr. It gives a relatively real-time estimate of where a storm is moving since real-time data is used as input to the forecast. This is an advantage over TYFN75 which, while utilizing real-time data as an input, is still relying on climatology for its forecast. Due to the relatively small sample size, it is recommended that the evaluation of XT24 continue during the 1976 typhoon season.

REFERENCES

- Colón, J. A., 1953: A Study of Hurricane Tracks for Forecasting Purposes. Mon. Wea. Rev., 81, 53-66.
- Harrison, E. J., 1975: Forecast Verification as a Function of Reconnaissance Platform. FLEWEACEN Tech Note: JTWC 75-2, 7 pp.
- Jarrell, J. D. and R. A. Wagoner, 1973: The 1972 Typhoon Analog Program (TYFOON-72). ENVPREDRSCHFAC Tech Paper No. 1-73, 44 pp.
- Riehl, H. and R. W. Sanborn, 1958: Climatology of Three-Day Hurricane Motion. Bull. Amer. Meteor. Soc., 39, 69-72.
- U. S. Fleet Weather Central/Joint Typhoon Warning Center, Guam. Annual Typhoon Reports, 1969-1975.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER FWC/JTWC TECH NOTE 76-4	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) MODIFIED TWENTY-FOUR HOUR EXTRAPOLATION AS A FORECAST TECHNIQUE FOR THE MOVEMENT OF TROPICAL CYCLONES		5. TYPE OF REPORT & PERIOD COVERED TECH NOTE (1973-1975)
7. AUTHOR(s) CHARLES R. SIKORA, CAPTAIN, USAF		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS FLEET WEATHER CENTRAL/JOINT TYPHOON WARNING CENTER (FLEWEACEN/JTWC), GUAM FPO SAN FRANCISCO 96630		8. CONTRACT OR GRANT NUMBER(s)
11. CONTROLLING OFFICE NAME AND ADDRESS FLEET WEATHER CENTRAL/JOINT TYPHOON WARNING CENTER (FLEWEACEN/JTWC), GUAM FPO SAN FRANCISCO 96630		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		12. REPORT DATE 1976
		13. NUMBER OF PAGES
		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) [REDACTED] APPROVED FOR PUBLIC RELEASE; [REDACTED]		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) TWENTY-FOUR HOUR EXTRAPOLATION (XT24) TWELVE-HOUR EXTRAPOLATION (XTRP) TYPHOON ANALOG (TYFN75) TYPHOON RECONNAISSANCE POSITION		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The Joint Typhoon Warning Center, Guam (JTWC) uses several objective techniques for forecasting the movement of tropical cyclones. Twelve-hour extrapolation (XTRP) and the TYFN75 analog program are the most successful of these techniques. The input parameters for both techniques include the past 12-hr storm position. It is felt that a subjective 24-hr extrapolation technique (XT24) based on reconnaissance positions is more → next page		

DD FORM 1 JAN 73 1473

EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

realistic: (1) these data are real-time whereas the warning positions are extrapolated from the reconnaissance positions and (2) a 24-hr period tends to smooth out erratic short-term movements in the storm track. An operational evaluation of XT24 was conducted during the 1975 typhoon season. These results and recommendations for future use are discussed.

Unclassified

Unclassified

DD FORM 1 JAN 73 1473

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)